HOW TO FIGHT THE CHINCH BUG

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THE CHINCH BUG is one of the most destructive native pests of grain and grass crops in the United States. The worst outbreaks occur in the great grain-raising region extending from Ohio to Oklahoma, Kansas, and Nebraska, but heavy losses also occur in the eastern and southeastern sections of the country. As far as is known, this insect feeds only on plants belonging to the grass family.

The chinch bug has two generations a year, and three in the extreme southern portion of its range. When full grown it is black with white markings, and is about one-sixth of an inch long.

The few natural enemies of this insect are not sufficient to prevent it from injuring crops, and spraying and dusting are too expensive to be recommended for general use.

The chinch bug can be fought most effectively (1) by growing immune or resistant crops or crop mixtures, (2) by modifying farm practices to prevent infestation, and (3) by the use of barrier traps to kill the bugs while they are migrating from small grains to corn or other susceptible crops.

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HOW TO FIGHT THE CHINCH BUG

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OCCURRENCE AND IMPORTANCE

THE CHINCH BUG is one of the most destructive of the native insects attacking grain and grass crops in the United States. It is of some importance in the southeastern and eastern sections of the country, but has reached its greatest abundance in the regions drained by the Mississippi, Ohio, and Missouri Rivers.

A knowledge of the best methods of controlling this insect has been sought by grain growers since its first general outbreak, which occurred about 1785. During the intervening 150 years there have been numerous chinch bug outbreaks, in some instances covering only parts of one or two States, but in others extending over a much wider area. The chinch bug's habit of feeding on the widely grown grains and grasses, its rapid rate of reproduction under favorable conditions, and its frequent occurrence in enormous numbers make it an extremely difficult pest to fight. The general use of insecticidal sprays is impractical, because chinch bugs feed by sucking the plant juices, and only poisons that kill by actual contact with the insect are effective. Other means of combating them must therefore be sought.

[1] Acknowledgment is due to W. P. Flint, G. H. Dungan, and J. H. Bigger for information taken from Illinois Agricultural Experiment Station Circular 431; to C. J. Drake, G. C. Decker, and A. D. Worthington for information and figs. 9 and 10 taken from Iowa Agricultural Extension Service Circular 213; and to Ralph O. Snelling for observations on the third generation in Oklahoma (Jour. Econ. Ent. 29: 797–803, illus. 1936). The photograph reproduced on the title page is used by courtesy of J. J. Davis, of the Indiana Agricultural Experiment Station, and the photograph used for fig. 7 was made by M. D. Farrar, of the Illinois Natural History Survey. Material from Farmers' Bulletin 1498, The Chinch Bug and How to Fight It, has been freely used.

WHAT THE CHINCH BUG LOOKS LIKE

The full-grown chinch bug (*Blissus leucopterus* Say) is a black insect with white markings, not over one-sixth of an inch long (figs. 1 and 5, *G*). Both long-winged and short-winged forms are found, but the long-winged form prevails throughout the Central States. It is capable of flying considerable distances, probably as far as 10 miles in a single flight when the wind is favorable. The short-winged individuals are unable to fly. In the East and North a somewhat more hairy species (*Blissus hirtus* Montd.) also occurs, especially in lawns and grassy areas. Short-winged individuals are usually more prevalent in that species.

FIGURE 1.—Chinch bugs, twice natural size.

SEASONAL HISTORY

Ordinarily there are two generations of the chinch bug each year throughout its entire range in this country, with a third generation in the extreme South, and occasionally a partial third generation farther north.

HOW AND WHERE CHINCH BUGS PASS THE WINTER

Chinch bugs pass the winter in the adult stage, hidden away in shelters that afford them good protection from the weather. They prefer to hide deep down in the tufts of the clump-forming native grasses (fig. 2). These grasses are known locally as bunch grass, bluestem, prairie grass, broomgrass, swale grass, beardgrass, and by several other names. The bugs also hibernate in clump-forming grasses, such as timothy, purpletop, orchard grass, dropseed, and sedges, especially where the so-called bunch grasses do not occur. Many bugs pass the winter under leaves and litter in the borders of woodlands and under hedges. Leaves or litter containing some grass (fig. 3) are preferred to either of these materials alone. From November to April the most likely places to find chinch bugs are the types of cover just described, especially on warm southern and western exposures where the sun shone during the afternoons of the preceding September and October when they were seeking winter quarters.

Chinch bugs may sometimes be found under the leaves of mullein or other weeds that form rosettes of large leaves at the surface of the ground, under the bark of dead trees and fence posts, under

boards and logs, in shocks of corn or standing cornstalks, in sorghum stubble, or under the loose boards and shingles of houses, in sheds and outbuildings, and in various other shelters. The percentage passing the winter in all such places, however, is small, and many of the bugs die.

FIGURE 2.—Bunchy perennial grasses like this are preferred by chinch bugs for winter quarters.

THE SPRING FLIGHT

The spring flights of overwintering bugs occur some time between February or March and the last part of May, depending on the season, on sunny days when for several hours the temperature remains at 70° F. or more, and usually only after 1 or 2 such days. In most years the flight is gradual, but sometimes nearly all the chinch bugs in a locality leave their winter shelters during 2 or 3 days of favor-

able weather. They usually settle in fields of small grain, especially in the thinner or poorer stands. The greater number of the bugs locate in wheat where that is the predominating small-grain crop, but they may often be found more abundant in rye or barley, where these grains are growing. In certain years, when oats have been planted early and cool weather has delayed the flight until the oats have made a good growth, many of the bugs may also settle in this crop. In such years a few of them may even fly direct to young corn.

Once in the fields of small grain, the bugs spend a few days feeding and mating before egg laying begins. Ordinarily little or no injury to the small grains is apparent as a result of their feeding, but in years of drought and heavy infestation they may seriously injure or even kill the small grains in which they settle. When conditions become unfavorable for them, either through the drying up

FIGURE 3.—Tufts of grass among woodland leaves are also favored places for hibernation.

of these grains or because of thick, rank growth, they often move to other fields or portions of fields more to their taste. Occasionally serious infestations of oats and corn occur in this way. There is often a considerable flight of the old bugs from the small grains to young corn after they have practically finished laying eggs. The sudden appearance of these spent adults in the cornfields is alarming, but needlessly so, since they soon die without doing much feeding or egg laying on the corn. The real danger at this time is from the young bugs they left behind them in the small grains.

DEVELOPMENT AND MIGRATION OF THE FIRST GENERATION

After the period of feeding and mating, the females begin to lay their eggs. These are deposited behind the lower leaf sheaths of the grain plants or in the ground around the plants, and in dry years when the ground is cracked they may be laid on the roots. The eggs ordinarily hatch in from 1 to 2 weeks. By wheat-harvest time the old bugs are practically all dead, and the young bugs of the new

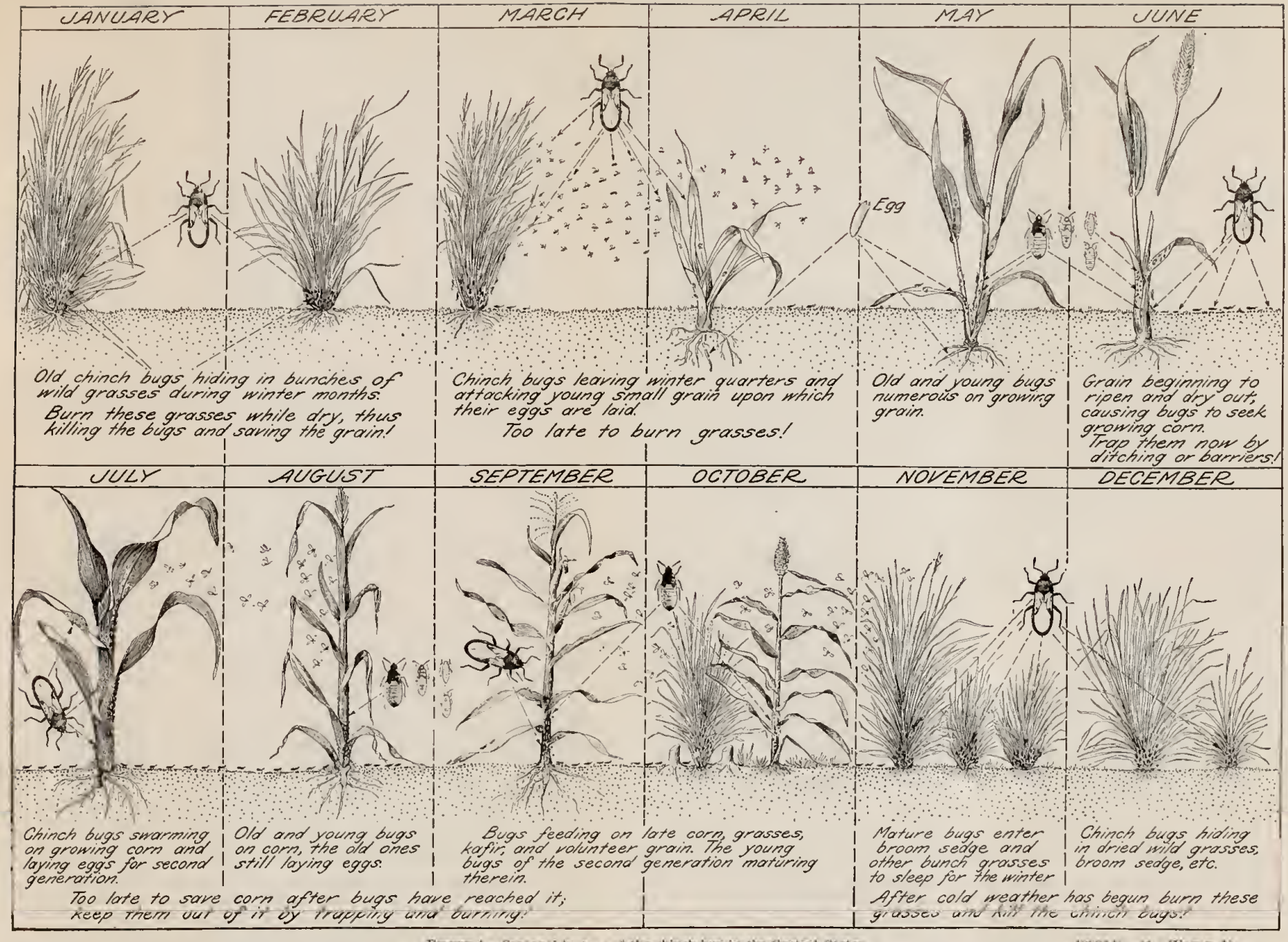

FIGURE 4.—Seasonal history of the chinch bug in the Central States.

generation are present in nearly all stages of growth, although still unable to fly. As the small grains ripen or dry up, the young bugs begin traveling on foot to find succulent food. They do this mainly in the afternoons of sunny days, although in cloudy weather there may be some movement throughout the day. At this time they move into adjacent fields of young corn, sorghum, or other plants of the grass family, where they resume feeding and complete their growth to the winged stage. It is during this migration that barrier-trap control (see p. 13) is effective.

THE SUMMER FLIGHT AND DEVELOPMENT OF LATER GENERATIONS

From 2 weeks to a month after the small grain is harvested there is a second flight to seek favorable host plants on which to feed and deposit eggs. It is during this flight that the bugs spread throughout the corn and sorghum fields, especially to thin stands or poor growth. As the summer advances, the adults of the first generation complete their egg laying and gradually die off, while the second generation hatches from these eggs and feeds mainly on corn, sorghum, foxtail, timothy, Sudan grass, and certain other grasses which may be in succulent condition during the summer. The second generation reaches the full-grown winged stage late in the summer or early in the fall. In the extreme South, where activity begins earlier in the spring and continues later in the fall, a third generation usually develops. Under particularly favorable conditions a partial third generation sometimes occurs as far north as Iowa.

THE FALL FLIGHT TO WINTER QUARTERS

The third, and last, flight occurs in the fall, when the adults of the second and third generations leave their summer food plants and seek hibernation quarters. Much of this flight seems to be rather gradual, beginning late in August and continuing through October and, in the South, even into November. General flights often occur, however, during the latter part of this period, particularly on very warm, sunny days following a period of frosty weather. The bugs seek winter quarters only on days when the sun is shining and while the temperature is at least 70° F.

Once in their winter quarters they became sluggish when the air temperature is low, and inactive when it is below freezing, but during periods of comparatively high temperature in the winter they may move about to a limited extent. Although they may take water, they apparently do not feed from the time they seek their winter quarters in the fall until they leave them in the spring. Some mating may occur before the spring flight. The seasonal history of this insect is summarized graphically in figure 4.

LIFE STAGES

The female chinch bug lays several hundred eggs at the rate of 15 or 20 a day; hence from 3 to 4 weeks may be required for her to lay her full quota. The eggs, which are about one thirty-second of an inch long (fig. 5, *A*), hatch in from 7 to 45 days, depending mainly upon the temperature. A very young bug (fig. 5, *B*) is about

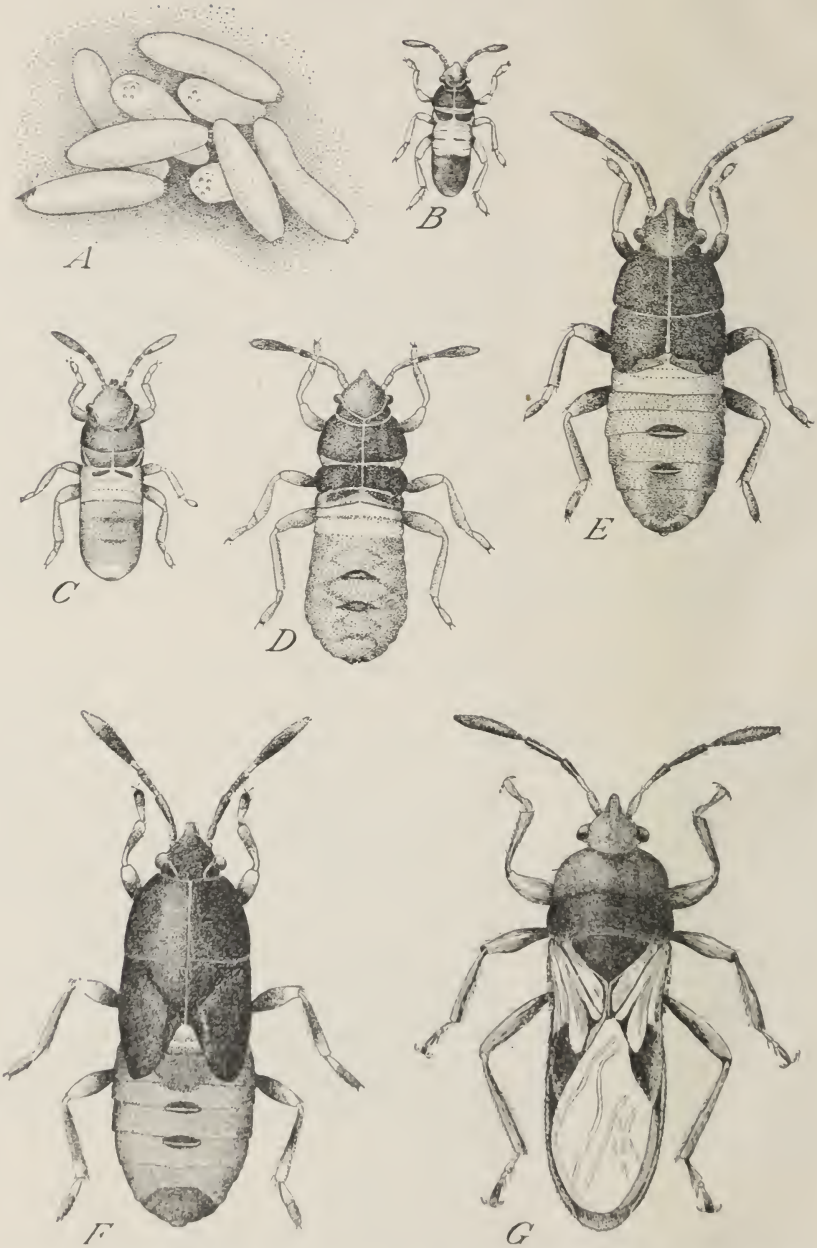

FIGURE 5.—The chinch bug: *A*, Eggs; *B*–*F*, the five immature stages; *G*, the winged adult. All greatly enlarged.

half the size of a pin head, and bright red marked with a transverse band of white. In the course of its growth its skin is shed five times, and each change gives it a darker coat until, in the last stage before acquiring wings, it has lost most of its red color and become grayish black with a conspicuous white spot on the back between the wing pads. In all these preliminary stages (fig. 5, *B–F*) the insect is wingless and has to depend entirely upon its legs for locomotion. In the sixth, or adult, stage the insect has wings, is about one-sixth of an inch long, and is black with white markings (fig. 5, *G*).

PLANTS ATTACKED

So far as is known, the chinch bug feeds only on plants belonging to the grass family. This includes all our small grains, corn, broomcorn, the sorghums, millet, Sudan grass, and other wild and cultivated grasses. Of the small grains, barley seems to be preferred above all others. It has been observed repeatedly that, where several kinds of small grains in practically the same stage of development are available to the bugs in the spring, barley is by far the most heavily infested. Barley, spring wheat, winter wheat, rye, and oats seem to be attacked in about the order named, although this order varies from year to year with the condition of the grains at the time of the spring flight. Where any one of these grains predominates, the chinch bugs readily feed upon it. During April, May, and June, after the spring flight, probably 90 percent of the bugs are found in the fields of small grains. Where the acreage of small grains is relatively low, the bugs may be found on timothy, junegrass, and several other wild grasses that appear during these months. Occasionally a few bugs occur on bluegrass, but apparently this grass is not succulent enough to be attractive, as the chinch bug feeds only by sucking, and it must have a food plant with a considerable flow of sap, as well as with stems that it can pierce readily with its beak.

Throughout the corn-growing sections the second generation of chinch bugs depends mainly upon corn for food (fig. 6), although it also feeds on other grains and grasses that may be in succulent condition late in the summer, including timothy, barnyard grass, tickle grass, crabgrass, foxtail, and bent and other lawn grasses.

PLANTS NOT INJURED

Fortunately, the chinch bug does not develop on any member of the great family of soil-building crops known as legumes. The clovers, alfalfa, vetch, lespedeza, soybeans, cowpeas, field peas, peanuts, and velvetbeans are all immune from chinch-bug injury. Other common crops not belonging to the grass family that may be grown during periods of chinch-bug abundance with the assurance that they will not be damaged are sunflower, flax, rape, stock beet, buckwheat, pumpkin, squash, and all the truck or garden crops except sweet corn. When the bugs are extremely abundant and their normal food plants become very scarce through the combined result of their ravages and drought, they sometimes try to feed on legumes and certain vegetable crops. They cannot feed successfully on these plants, however, and only rarely do they attempt to do so in numbers

large enough to cause any injury. *The substitution of legumes and other immune crops for small grains and corn offers one of the most important and valuable ways of avoiding or overcoming trouble due to chinch bugs.*

IMPORTANCE OF WEATHER IN CHINCH BUG ABUNDANCE

The weather is the chief factor governing the abundance of chinch bugs. They are most susceptible to weather conditions while they are hatching. The hatching period of the first generation extends from April to about the middle of June, and that of the second generation from the middle of July to the middle of September, with

FIGURE 6.—Corn damaged by invasion of chinch bugs from adjacent small grain. This could have been prevented by timely use of a good barrier or by not planting corn and small grain in adjoining fields.

some variation according to the latitude. Frequent heavy, driving rains during these periods beat the young bugs into the mud, from which they are unable to escape. Such storms also cover the eggs with mud and prevent them from hatching, and keep the females from laying their full number of eggs. As a result the bugs may be of little importance as farm pests for several seasons. Frequent rains or periods of warm, damp weather also favor the development of the chinch bugs' worst natural enemy, the white-fungus disease.

Chinch bugs are less able to survive an open, wet winter than a cold one with heavy snow cover. Many bugs are also killed by sudden changes in temperature, extremely low temperatures while there is little snow cover, or the formation of ice in their hibernation quarters due to a sudden freeze following a thaw or rain. In the Middle West, however, less than 10 percent of the bugs die in a normal winter.

All the recorded outbreaks of the chinch bug have begun during periods of normal or less than normal rainfall, and it has usually

been several years before adverse weather and other natural conditions were able to reduce the number of bugs to the point where they became unimportant. One of the most persistent outbreaks originated in 1910 in Illinois, Missouri, and Kansas, and, except in 1915, when an extremely wet summer greatly reduced their number, losses occurred every year until 1925. Again in 1930 lack of rainfall during the breeding season allowed increases in chinch bug abundance which culminated in 1934 in the most severe and widespread outbreak ever known. Populations were greatly reduced in 1935, locally by winter mortality but mainly by the widespread cold, rainy weather in May and June, which delayed the spring flight, reduced egg laying, and destroyed many bugs of the first generation as they hatched. Shortage of rainfall, however, during the remainder of the season, and again in 1936, favored chinch bug increase, until at the end of 1936 threatening numbers were again present in several Midwestern States.

NATURAL ENEMIES

Probably the most destructive natural enemy of the chinch bug is the white-fungus disease (*Beauveria globulifera*). It is generally present in the fields throughout the country, but its effectiveness is dependent on the weather. Since it has been proved that the spores of this fungus are present wherever the bugs are common, its artificial dissemination as a control measure is needless.

Next in importance is a tiny wasplike parasitic insect (*Eumicrosoma beneficа* Gahan). This little wasp lays an egg in the chinch bug egg. The maggot hatching from the wasp egg consumes the contents and develops inside the chinch bug egg, and when this maggot becomes full grown it changes to the adult wasp, which emerges from that egg instead of a chinch bug. This beneficial insect is so small that it is probably never seen by farmers. When held in the palm of the hand, it appears to be merely a dark speck, and only microscopic examination reveals it as an insect; yet records show that it has parasitized from 30 to 50 percent of the chinch bug eggs in certain localities. Such a high percentage of parasitization is unusual, however. It is known to occur over most of the States of the Middle West and in one Eastern State, but has not been taken in the far West.

Several other fungus diseases and insects also attack the chinch bug; and a number of birds, including the bobwhite, the red-winged blackbird, the catbird, the brown thrasher, and the meadowlark, are known to feed on it. More than 200 chinch bugs were found in the stomach of a single brown thrasher and more than 100 each in the stomachs of a bobwhite and a meadowlark. Many other birds have taken from 5 to 50 chinch bugs at a single meal. None of these, however, appear to be important factors in its control more than to aid other natural enemies in preventing serious outbreaks.

CONTROL MEASURES

There is so much uncertainty about the duration of chinch bug outbreaks that it is never safe for the grain grower to depend upon natural agencies to curb losses from them. Various methods of con-

trol, including spraying and dusting, have been tried, but there are only three measures that have proved generally practical. The following methods can be used effectively under actual farm conditions, as will be explained, and by their use losses due to chinch bugs can be materially reduced: (1) Growing immune or resistant crops or crop mixtures, (2) modifying farm practices to prevent infestation, and (3) using barrier traps to kill the bugs while they are migrating from small grains to corn or other susceptible crops.

GROWING IMMUNE OR RESISTANT CROPS

Since the first-generation bugs depend mainly on small grains for their food, and those of the second generation feed mostly on corn and sorghum, a good way to hold this insect in check is to make its food supply as scarce as possible. This can be done by reducing the acreage of small grains where corn and sorghum are the leading crops, and that of corn and sorghum where small grains predominate, and planting legumes or other immune crops in their place. In this way one of the generations of bugs will be severely handicapped.

For a farm especially well adapted to corn production, a rotation of corn, soybeans, corn, oats, or wheat and clover will result in as little loss as any that includes both small grain and corn. With this rotation corn would occupy about 40 percent and the other crops each about 20 percent of the cropped land each year. In areas better suited to the production of small grains a rotation may be used in which wheat or oats, clover, corn, and soybeans each occupies about 25 percent of the cropped land each year. The most suitable rotation for any particular farm where the chinch bug is a problem, however, can best be ascertained from the county agent or State agricultural experiment station.

Legumes should not only be grown by themselves, but where practical they may well be planted among small grains and corn. Apparently there is nothing about these crops that is repellent to chinch bugs, since they will alight upon and crawl over or through them, and may even try to feed on them when forced to it by extreme starvation. Legumes are practically immune from chinch bug injury, however, and the growing of the clovers, alfalfa, or vetch among small grains and of soybeans or cowpeas among corn often helps to produce a condition of shade and dampness around the lower parts of the grain plants that is unfavorable to the bugs and is avoided by them.

Experiments in growing corn with and without soybeans or cowpeas have shown that considerable protection is afforded the corn by these legumes. In the presence of chinch bug infestations corn grown with soybeans or cowpeas has outyielded corn grown without these legumes by from 2 to 15 bushels per acre. The degree of benefit depends on the number of chinch bugs present, the fertility of the soil, and the weather. In extremely dry weather, with a heavy infestation of chinch bugs, the beneficial effect of the legumes may not be great, and possibly the bugs may destroy all the corn in the field. Even under such conditions, when planted at the rate of three beans per hill of corn, the soybeans themselves have yielded from 10 to 12 bushels per acre. Under nearly all conditions they

may be expected to make sufficient growth to afford good pasturage for hogs, sheep, and cattle, and to give at least a partial crop on the land.

It has been found that certain strains or varieties of corn and sorghum are decidedly resistant to the attacks of the second-generation bugs, although they need protection from the first generation. Certain types of sorghums, however, particularly the milos, Honey sorgo, and Bishop kafir, are so susceptible to chinch bug injury that they are not ordinarily grown where chinch bugs are prevalent. In southern Illinois the corn varieties Black Hawk, Champion White Pearl (sometimes called Democrat), Golden Beauty, Mohawk, Waddell Utility white dent, and Waddell Utility yellow dent have made fair yields under heavy infestations which so badly damaged other varieties grown in the same field that they produced very little grain. None of these varieties, however, is chinch bug proof. Practically as many bugs occur on the resistant as on the nonresistant varieties of corn. As these varieties require a long growing season, they are not suitable for more northern locations.

In recent years much progress has been made in Illinois, Kansas, and Oklahoma with the development of hybrid corns and sorghums distinctly resistant to second-generation chinch bugs. These results open up the possibility of finding resistant varieties and hybrids adapted to other regions as well. The best of these hybrids are much more resistant than the open-pollinated varieties. When seed of resistant hybrids is available, it should be used in preference to less resistant varieties. Some hybrids, however, are decidedly susceptible to chinch bug injury and should be avoided. When seed of resistant hybrid corn adapted to any particular locality is not available, it is recommended that the highest yielding hybrids or open-pollinated varieties known to be suited to that locality be grown in preference to untried resistant corns brought in from some other section. For information concerning the best resistant varieties of corn or sorghum for your locality, consult your county agent or State experiment station.

MODIFYING FARM PRACTICES TO REDUCE INFESTATION

When it is not practical to eliminate or even to reduce materially the acreage of small grains on farms where the chinch bug is a problem, it becomes necessary to take other measures to reduce infestations in these grains.

The first measure is the selection of the kind to plant, where a choice can be made. Chinch bugs will feed and breed abundantly in any of the small grains under the right conditions; hence none of them can be depended upon for use as a trap crop in which the bugs may be effectively concentrated and destroyed. The comparative attractiveness of the small grains varies with the condition of the grains in different years or areas, but it is usually in about the following order: Barley, spring wheat, winter wheat, rye, and oats. The planting of spring barley should especially be avoided when there is a prospect of chinch bug abundance, and, where feasible, the other small-grain plantings should be adjusted to reduce the acreages of wheat and rye and make use of oats instead.

In the more southern areas, such as central and southern Missouri, winter barley sown early in the fall produces in the spring a thick growth that is less attractive to chinch bugs than spring-sown barley. Furthermore, the winter barley matures so early that it can be harvested before the first-generation bugs have injured it materially or have had opportunity to make much growth. The barley can be used awhile for spring pasture, or harvested for grain, and the ground then plowed up for replanting to soybeans the same season, the bugs being destroyed in the process before they are able to migrate to other crops. In some of these areas the advantages to be gained through the use of winter barley sown early in the fall for pasture appear to outweigh the objection to this crop on account of its attractiveness to chinch bugs.

Another helpful measure is the stimulation of a thick, vigorous growth of grain. Chinch bugs seldom congregate or breed in heavy stands of any small grain; hence anything that can be done to produce this condition, such as thorough tillage, ample fertilization, and timely seeding, helps to reduce injury from the bugs. Even winter wheat can be planted with fair assurance that chinch bugs will not breed in it abundantly, provided a thick, vigorous spring growth can be obtained. A dense growth of clover in small grain also helps to bring about a damp, shady condition that is unfavorable to the bugs.

In dry seasons when there are severe infestations, ruined fields of small grain can sometimes be disked or plowed up to advantage to destroy the bugs, and replanted with soybeans or some other immune crop. Before such a field is plowed, a dust barrier, as described later, should be prepared to prevent migration of the bugs into adjacent grain or grass fields. Immediately after being plowed, the entire field should be thoroughly cultivated to destroy all green growth and to produce a good dust mulch. By these means the bugs usually can be starved to death or otherwise killed and are thus no longer a menace to the succeeding or adjacent crops. Corn or a quick-growing grass crop can be planted after such treatment, provided the dust mulch has been maintained until all eggs have hatched and the bugs in the field have all been killed.

Where migrating bugs have ruined young corn, it is often possible to disk the ground and replant to soybeans, thus securing a worthwhile crop from the land even though the original crop of corn is lost. Injury to corn and sorghums can be partly evaded by early planting.

Still another way of reducing chinch bug damage is to adjust the cropping system so as to avoid adjacent plantings of small grain and corn. Where this is not possible, plans should be made to run a creosote barrier between the plantings if necessary, and just before harvest time close watch should be kept for chinch bugs in the small grains to determine whether or not migration to corn may be expected. Neighbors can often cooperate to advantage by arranging to plant corn in adjoining fields, or otherwise to avoid the growing of small grain and corn adjacent to each other.

In the more western regions, where the native bunch grasses form the principal shelter, burning over the most favored hibernation quarters while the bugs are in them, some time between November

1 and March 15, may help to reduce their numbers. On the other hand, in regions where the bunch grasses are uncommon and many of the bugs hibernate in other types of shelter, winter burning is not a practical or effective method of control. Woodlands should never be burned over, because the harm resulting from destruction of the young growth and wildlife refuges will more than offset the benefit. The natural bird shelters in unwooded areas also should be left unburned or, if burned, should be replaced by a few brush piles or corn shocks. An additional objection to the burning over of grasslands is that it increases the danger of erosion. Because of the injury to the stand and the reduction in growth the following summer, permanent pastures and hayfields should not be burned. The burning of small-grain stubble and cornstalks is not warranted, be-

FIGURE 7.—Corn at left ruined by invasion of chinch bugs from adjacent small grain, that on the right saved by a creosote barrier. (Illinois State Natural History Survey.)

cause very few bugs winter over successfully in such cover. *All things considered, indiscriminate and wholesale burning is likely to do more harm than good.*

BARRIERS

One of the oldest and best methods for controlling chinch bugs is the use, at harvest time, of barriers along which the young bugs can be killed as they crawl from the ripening small-grain fields into corn or into small grains that may still be green. As chinch bugs are dependent on succulent plants for food, they are compelled to leave the small grain when it ripens and dries or is cut. At this time only a few bugs have reached the full-grown, or winged, stage, and most of them have to migrate on foot. By the timely construction and maintenance of barriers it is possible to prevent most of the damage done to corn or previously uninfested small grain by the bugs migrating to it on foot (fig. 7), and also to reduce the damage to

corn by their progeny later in the summer. The saving of only 1 acre of corn more than repays the cost of 80 rods of barrier. In one instance 8 bushels of bugs were caught along half a mile of creosote barrier in a week, and approximately the same quantity in the same field the next week. By counts of single quarts of chinch bugs it was estimated that at least 60 million chinch bugs were caught along this line in 1 week.

Barriers are not effective in controlling the bugs after they have acquired wings. In the more southern areas the bugs may be winged before they leave the small grains, thus rendering the barriers totally ineffective.

MATERIALS USED

Many kinds of barriers have been tried, and several have been found effective. Field tests have shown that oils with a fairly light body are most easily applied, soak into soil or paper readily, and, unless applied too heavily, do not run down at right angles to the line and thus reduce the efficiency of the barrier. Heavy oils lose their effectiveness sooner through loss of odor, hardening, or drying, and becoming covered with dust.

Coal-tar creosote has been used extensively for a number of years, and this material is the best of any thus far tested. Coal-tar creosote, Federal Specification TT–W–556,[2] is recommended above all others because of its repellent and lasting qualities, low viscosity, ready availability in large quantities, and low price. *Coal-tar creosote and its fumes have a caustic effect on the skin, and this material is also poisonous when taken internally.* These facts should be kept in mind when working with this material, and close contact with it should be avoided as much as possible. Coating the hands and face with petrolatum or cup grease helps to prevent creosote burns.

Other materials have been found effective in the following order: Naphthalene drain oil, gas tar, pine-tar oil, and wood creosote. Any of these that have a strong odor of naphthalene, creosote, or phenol can be used to good effect if it can be purchased cheaply.

THE DIRT-RIDGE CREOSOTE BARRIER

The foundation for a creosote barrier is best made by throwing up a ridge of earth with a plow, turning the dirt toward the corn. A disk cultivator or small road grader may be used instead of a plow if more convenient. The side of the ridge toward the bugs should be smoothed and packed with a section of a harrow or a narrow drag so that it is free from clods, cracks, or trash. If necessary, the upper part of the ridge should be firmed with a shovel. A line of creosote is then applied, as shown in figure 8, along the brow of the ridge but not quite on top of it, so that the bugs are still climbing upward when they reach it but are not yet at the top where they are likely to be blown across the line by the wind. If the line is placed either in the bottom of the furrow or on the top of the ridge, the foremost

[2] Dealers in coal-tar creosote are usually familiar with these specifications. If not, a copy of them may be obtained from the Superintendent of Documents, Washington, D. C. Price 5 cents.

bugs are likely to be pushed across by those crowding up behind them.

A convenient container to use for applying the creosote is a tin or galvanized bucket in the side of which a hole has been punched with an eightpenny nail. The hole should be about 1 inch from the bottom so that it is not readily clogged, and should be directly below the point where the bail is attached. The creosote is allowed to run from this hole as the bucket is carried along the barrier. A line one-half inch wide is just as effective as one 2 or 3 inches wide. Therefore, only a small quantity is necessary for one application. Fresh creosote should be applied to the original line at least once a day for the first few days; after this, if care has been taken to follow the same line each time, it need be renewed only once every 2 or 3 days, unless the weather is extremely hot and dry.

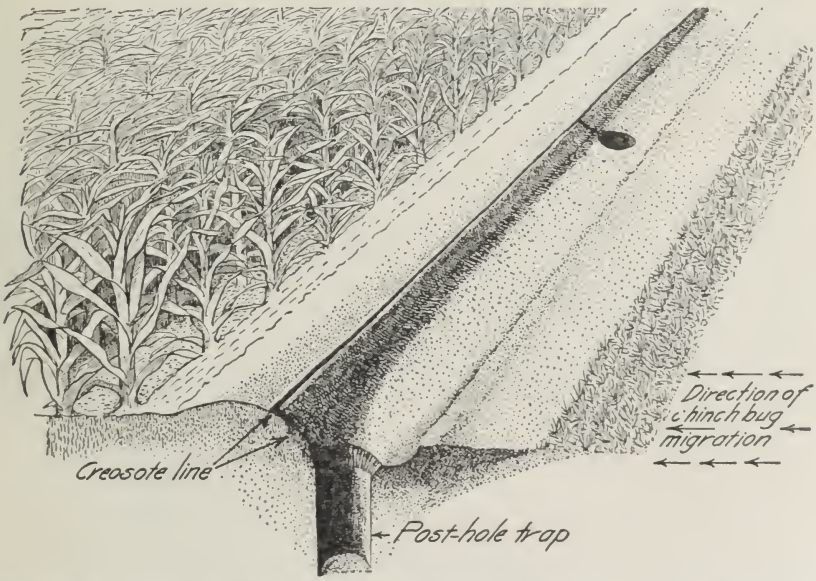

FIGURE 8.—A dirt-ridge creosote barrier. Very efficient if creosote line and post-hole traps are properly constructed and maintained.

When poured on the ground the creosote sinks in immediately, making a brownish line on the surface, and giving off a strong odor that is very repellent to the bugs. This repellent odor seems to be all that keeps them from crossing the line, and if it has been properly located very few actually do so. Light rains have the effect of freshening the creosote, as it is oily and comes to the surface when the ground is wet. When properly applied, 50 gallons of creosote will maintain a quarter of a mile of barrier for about 3 weeks, which ordinarily is longer than the barrier is required.

Post holes for trapping the bugs should be dug in the furrow from 1 to 4 rods apart and from 18 to 20 inches deep. The more numerous the bugs, the closer should be the holes. They should be set part way into the ridge, and their rims should be steeply flared all around with the slope extended well up toward the creosote line.

The flared ring should also be kept covered with fine dust. The bugs traveling toward the cornfield encounter the creosote line, begin moving along it in an attempt to find a crossing, lose their footing in the loose dust, and tumble into the post holes. Few of them can crawl out if the rims of the holes are kept dusty. Trapping the bugs in the post holes and destroying them is fully as important as stopping their migration. This feature of barrier operation is too often neglected.

After completion this type of barrier should not be dragged, and it should be kept in good repair. The efficiency of the post-hole traps must be maintained continuously by means of fresh dust around their rims when needed. If dust is not available from the dirt floor of a barn or shed, a bushel or so should be stored away for use in case rain spoils that usually available in the field.

The bugs trapped in the holes should be killed every afternoon at about sundown. An easy way of doing this is to sprinkle 1 or 2 tablespoonfuls of kerosene into each hole. Do not ignite the kerosene, but let the bugs work it around among themselves.

THE CREOSOTE-TREATED PAPER-FENCE BARRIER

A paper-fence barrier has been developed and rather widely used in Iowa and Illinois. It is made by setting upright in the ground a strip of creosote-soaked paper about 4 inches wide, with half its width above the surface (fig. 9). Experience has shown that the 4-inch width is the best for practical use, and that the strip is most effective when placed 2 inches below and 2 inches above the ground. This 2-inch fence of creosoted paper acts as a physical as well as a chemical barrier and prevents the bugs from being blown across the line by wind or crowded across by their fellows. It also helps to avoid bridging of the line by straws, leaves, or dust; breaks in the barrier due to cracking of the soil in dry weather; and injury to the soil by the creosote. Although the treated paper fence is installed with more difficulty than the creosote line applied directly on the soil, it is less troublesome and expensive to maintain effectively in all kinds of soil and weather when properly made with paper of the right kind. Paper fences can be installed either on the usual type of furrow and ridge described and illustrated above or on clean, level ground as shown in figure 9. Where the barrier is likely to be submerged by the accumulation of rain water in low spots, its location on a ridge is preferable. After the paper has been prepared, two men can build 80 rods of paper fence in about 4 hours.

Single-faced corrugated paper, tarred (not asphalt-treated) felt paper of the 14- or 15-pound grade, red-rosin building paper of the 30-pound grade or heavier, and heavy chip board or chip strawboard ranging from 20 to 40 points in thickness have been used successfully. The choice of paper is usually determined by availability and cost. The rolls as purchased are first cut with a crosscut saw into narrower rolls about 4 inches wide. With some papers it is necessary to oil the saw blade or clean it occasionally with kerosene. After being cut, the rolls should be soaked for at least 12 hours in a container with enough creosote to keep them covered.

They should then be allowed to drain for an hour or more before the fence is built.

The manner of erecting the treated paper fence depends upon the tools available and the character of the soil. A handy tool for use in unrolling and installing the paper strips may be made by fitting a broom handle into a hole in the side of a piece of 2 by 4 about a foot long, so as to form a T-shaped carrier, and slipping the roll of paper down over the handle until it rests on the crosspiece at the bottom. After a ridge or a smooth path free from litter has been prepared, a wheel hoe or a garden cultivator with a small plow attachment, or a corn cultivator with all but one shovel removed, may be used to open a small furrow to receive the paper.

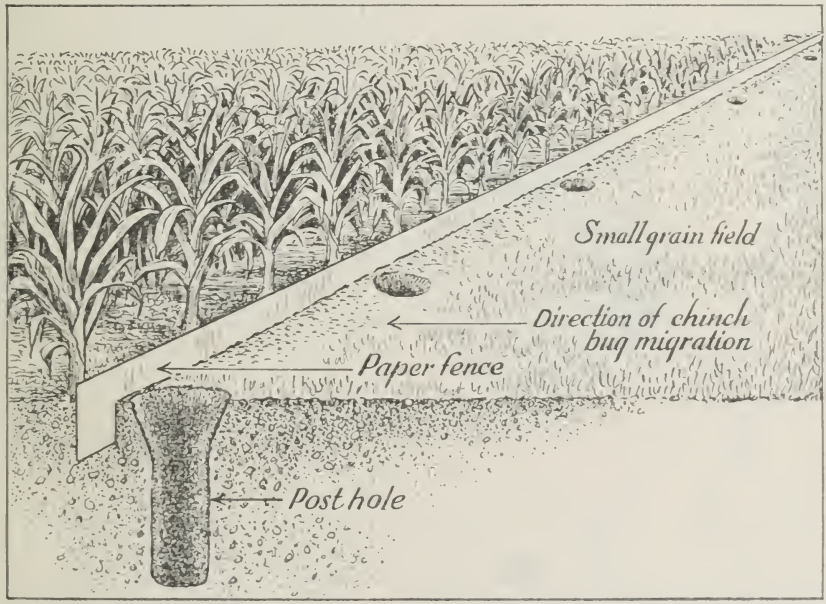

FIGURE 9.—Creosote-treated paper-fence barrier, a recent improvement over the creosote ground-line type. (Iowa State Agricultural Experiment Station.)

When the ground is very hard, it may be necessary to use a turnplow. In this case the paper is unrolled against the straight, or land, side of the furrow and the dirt is packed against it. In any event it is important that the dirt be packed firmly and evenly to the same level on both sides of the paper, for if it is left higher on one side than on the other, rain water or caving soil may cause greater pressure on the higher side, resulting in a collapse of the fence.

Post holes for trapping and killing the bugs are just as important with paper fences as with the ground-line creosote barriers. They should be dug every 1 to 4 rods on the side of the paper toward the small grain and from 4 to 6 inches away from it, with their edges sloped out almost to the paper and then dusted.

The paper fence should repel the bugs for 2 or 3 days, if it has been properly treated. Then it will have to be freshened by applying more creosote close to the top edge of the paper. A bucket with a

hole near the bottom as described on page 15 can be used for this purpose, but the application can be made much more easily if a copper tube is soldered into the hole so as to extend downward for 12 or 15 inches, its end being curved sideways to direct the stream against the paper. A horizontal prong is soldered to it close to the lower end to slide along the top edge of the paper and act as a guide (fig. 10). A single treatment of one-fourth mile of 2-inch paper fence requires 2 or 3 gallons of creosote. After it is well soaked, the paper barrier will not need retreatment so frequently as a creosote line on the ground.

The treated paper barrier costs about the same as the dirt-ridge ground-line creosote barrier. About 30 gallons of creosote will ordinarily be sufficient to maintain a quarter of a mile of paper-fence barrier for the season. This is about two-thirds the quantity required for the ground-line type. Enough paper for a quarter-mile of 4-inch strips costs approximately $2. With creosote at 20 cents a gallon, the cost of paper barrier would thus be $6 for the creosote plus $2 for the paper, or a total of $8 per quarter mile.

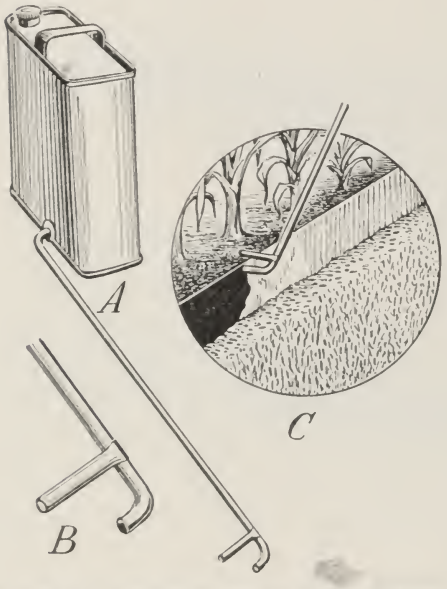

FIGURE 10.—Renewing creosote on paper fence: *A*, Receptacle with a copper tube; *B*, guide prong soldered near end of tube; *C*, applying creosote to paper fence. (Iowa State Agricultural Experiment Station.)

CREOSOTE-TREATED ROPE FENCE

Another type of creosote barrier that found some favor in Ohio in 1935 is made by using, instead of the paper strip, a special kind of soft rope about one-half inch in diameter. A smooth, well-packed path is first made along the side of the field to be protected. The rope is then laid in place on this path, and one end is threaded through a specially designed creosote applicator, which consists of a bucket containing a fixture bearing spools to guide the rope down into the creosote and out again on the other side of the bucket. The end of the rope is then fastened to a stake, and the applicator is carried along so that the rope runs through it and drops back soaked with creosote into its position on the barrier path. The use of post holes to trap the bugs is just as essential with the rope barrier as with the other types.

The rope barrier costs about the same as the paper fence or ground-line type of creosote barrier and can be installed more easily. Where a smooth path free from lumps and cracks can be made, it is very satisfactory. While it acts somewhat as a physical as well as a chemical barrier, it is not so efficient in this respect as the paper fence, for it is easily knocked or blown out of place and, where the ground is lumpy or cracked, it does not make good contact with the soil

surface. Under such conditions the rope barrier is little, if any, improvement over a ground line of creosote, because its effectiveness then depends on whether or not the creosote dripping from the rope has formed an unbroken line on the ground beneath it.

COAL-TAR OR GAS-TAR BARRIER

A well-known type of barrier is made by pouring a narrow line of coal tar or gas tar on a path made by smoothing and packing the soil as firmly as possible along the margin of the field to be protected. Chinch bugs are repelled by the odor of the tar, and while the tar is fresh it also acts as a physical barrier because of its stickiness. Tar makes a very effective barrier, but it has to be renewed oftener than creosote. Where the proper grade can be obtained cheaply and readily, its use is highly practical. Tars from which the creosote and cresylic acids have not been distilled should be procured, for tars from which these materials have been removed, and also tars resulting from the manufacture of water gas, have little or no value as chinch bug repellents. Post holes properly dug and maintained are also essential to the effective operation of tar barriers.

BURNING ALONG THE BARRIER NOT RECOMMENDED

It is possible to kill nearly all the chinch bugs along a barrier by flaming with a large blowtorch, but this method is not recommended, since practically the same result can be attained at much less expense by the use of the post-hole traps. Bugs congregating on the outer rows of corn may be killed by flaming them with a torch, but in nearly every case the plants also will be killed. A better procedure is to disk up the ruined portion of the field and plant it to soybeans.

THE DUSTY-FURROW BARRIER

The oldest and most widely used barrier consists of a dusty furrow or strip around the field to be protected. The furrow type is the best and is generally made by plowing a dead furrow, throwing the dirt both ways, and then dragging a log or trough of planks back and forth in this furrow until the sides and bottom have been worked down to a fine dust. Sometimes two parallel furrows are plowed, and a double drag is constructed with a raised connection to span the intervening ridge. Both furrows may thus be dragged with little more labor than would be required for a single furrow. Effective dust barriers have also been maintained by repeatedly dragging a harrow back and forth over a strip of ground across the field in front of the bugs, thus working up a deep, fine dust mulch in which the bugs are buried and killed as they crawl into it. No post holes are used with barriers that depend on a dust mulch for their effectiveness.

On certain types of soil, and during dry weather, dust barriers are very satisfactory. While dry they remain impassable to chinch bugs if frequently dragged, and most of the bugs that fall into them are killed by the drag, the heat of the sun, or the penetration of fine particles of dust into their breathing tubes. Of course, dust barriers are of no value during periods of rain. Often a heavy

shower ruins the dust mulch so that the bugs are able to cross in sufficient numbers to destroy 1 or 2 acres of corn before a fresh dust can be worked up. Also, in some soils it is impossible to make a dust so fine that the chinch bugs cannot crawl through it. Although the dust barrier does not require any costly equipment or the expenditure of money for materials, constant labor is necessary to maintain it, and the expense is often greater than for a more dependable and efficient creosote or tar barrier.

BARRIERS THAT ARE OF LITTLE OR NO VALUE

A number of suggested chinch bug barriers have proved to be practically worthless. Barriers made by planting a narrow strip of some legume between the small grain and the corn are of little or no value. Cowpeas or soybeans are the legumes most frequently used in this way, but the bugs crawl through them about as readily as they would pass over the bare ground. It has also been suggested that the bugs would feed upon freshly cut cornstalks laid in a continuous line along the margin of the grainfield, and would be poisoned by this material as it soured. Numerous tests with this type of barrier have shown that it is worthless. Occasionally considerable numbers of cast-off skins of the bugs may be found scattered through the cornstalks, and these are often mistaken for dead bugs. Close examination, however, has failed to show that any chinch bugs are killed by this kind of a barrier.

SPRAYING AND DUSTING WITH INSECTICIDES AS EMERGENCY MEASURES

Spraying and dusting with insecticides are expensive operations and thus far have not been found practical for controlling chinch bugs in large fields of either small grain or corn. They are recommended only as emergency measures where the bugs have invaded small plantings of valuable seed corn. In such cases satisfactory results require the use of an efficient knapsack sprayer or duster. Since chinch bugs do not eat plant tissue, but feed only by piercing the stems or leaves with their sharp beaks and sucking the sap, they cannot be killed by poison sprayed or dusted on the plants. The bugs themselves must be hit with a spray or dust that will kill them upon contact. This is usually difficult to do thoroughly, because many of them are hidden under leaf sheaths and foliage or are moving about on the ground.

One of the best sprays for this purpose consists of one-half ounce of 40-percent nicotine sulphate and 1 ounce of soap, dissolved in 1 gallon of water. This spray will kill all bugs wet with it and is not injurious to the corn except when applied so that it accumulates in the heart or curl of the plant. Where this occurs, the soap sometimes kills the leaves when the water evaporates. Solutions made with certain grades of laundry soap, without the nicotine sulphate, make fairly effective sprays. With soft water, 3 or 3½ ounces of soap to a gallon is sufficient, but more is necessary if the water is hard. All chinch bugs thoroughly wet with the soap solution will be killed, but soap sprays must be used with caution, as they may injure the corn.

When chinch bugs are congregated on the first rows of corn, dusting is sometimes more effective than spraying. Less labor is required for dusting and, although the material costs more, dusting can often be done to better advantage. A few of the bugs on the outer leaves of the plant may escape the dust, but nearly all can be killed. A 2.4-percent nicotine dust is harmless to corn plants, is very effective in killing chinch bugs, and may be applied at a fairly rapid rate. It is better to buy this dust ready mixed, especially if the quantity needed is small.

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